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ABSTRACT

Presented is a description and copy of a test manual developed to include items in the test on the basis of children's performance; each item correlated highly with performance on an external criterion. The external criterion was the Individual Competency Measures of the elementary science program Science - A Process Approach (SAPA). The test administrator evaluates the subject's ability to use the processes as he works with materials in solving problems the administrator poses. The processes included are those referred to by SAPA as interpreting data, controlling variables, formulating hypotheses, and defining operationally. Attention was given during item writing and editing to maintain the reading level as low as possible; the final revision was at the sixth-grade level. The test is not intended to be a timed test, nor is it a factual test. Thinking is required to achieve a high score. Most students will complete it in less than 45 minutes. A test-answer sheet is included with this publication, but no test copy.

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DEVELOPMENT OF
THE SCIENCE PROCESSES TEST

by

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BEST COPY AVAILABLE

A paper presented at the annual meeting
of the National Association for Research
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TEST MANUAL

THE
SCIENCE
PROCESSES
TEST

FORM D
(1974)

by

ROBERT R. LUDEMAN
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THE SCIENCE PROCESSES TEST
(TSPT)

TEST MANUAL

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Rationale

A more complete description of the rationale and development of TSPT is published elsewhere.¹

The expressions of need voiced by researchers in science education for efficient valid tests of science processes coupled with the difficulty usually encountered in developing such tests prompted a group of individuals in the Science and Math Teaching Center at Michigan State University to employ a method of test development that is different from the traditional test development procedure. TSPT is the result of that effort.

¹Robert R. Ludeman, Development of The Science Processes Test, unpublished dissertation, (Michigan State University, 1974).

Most tests rely on "expert" opinion for their claim of content type validity. This procedure is especially subject to question for a test intended to evaluate children's ability to use the processes of science since it has been found that writing process test items is much more difficult than writing simple factual recall items. Therefore, in the development of TSPT, although this procedure was used for the original generation of test items, in the later stages of test development, this procedure was replaced by a procedure known as "external criterion referenced validation." Using this procedure, items are included in the test on the basis of the requirement that children's performance on each item be highly correlated with their performance on the external criterion. In this case, the external criterion is the Individual Competency Measures of the elementary science program Science - A Process Approach (SAPA).²

The Individual Competency Measures consist of individualized testing situations using the same materials and contexts used by SAPA in defining the Science Processes. The test administrator evaluates the subject's ability to use the Processes as he works with materials in solving problems the administrator poses. The Individual Competency Measures are not widely used because of their low time-efficiency but since they are so directly related to the context which defines the Processes, it seems reasonable to assume that they constitute an accurate assessment of student's ability and can be used as the criterion for validation of a more time-efficient test.

The science processes addressed by TSPT are the integrated processes referred to by SAPA as Interpreting Data, Controlling Variables, Formulating Hypotheses, and Defining Operationally. It is assumed that the Individual Competency Measures do indeed measure children's ability

² American Association for the Advancement of Science, Science - A Process Approach Commentary for Teachers, AAAS Misc. Publication 68-7, 1968.

to use these processes and that a high correlation of children's performance on the Individual Competency Measures with their performance on TSPT therefore may be taken as evidence that TSPT is a valid measure of children's ability to use the processes of science.

Development of TSPT:

Based on the behavioral objectives of SAPA, 113 multiple choice items were originally written and examined by science educators with reference to their relevance to these objectives. These items were tried out and revised three times on the basis of conventional test development procedures (all alternatives chosen by some students, discrimination greater than .3, difficulty between .2 and .7) with many items being either discarded or rewritten to meet these requirements. In this phase of the development which was completed in the spring of 1973, 367 sixth-grade students were involved. At this point it was felt that the resulting item pool of 61 items was of adequate technical quality to begin the criterion-validation phase of the development. Accordingly, beginning early in November and continuing through December of 1973 the Individual Competency Measures of SAPA were administered to 52 sixth-grade children. Immediately on completion of the administration of the Individual Competency Measures the above 61 items were administered to the same 52 children. Their performance on the Individual Competency Measures was then used as the criterion for item selection for inclusion in TSPT, using the following requirements:

1. All alternatives have been chosen by some students.
2. The context of the item allows its use.
In some cases, since more than one item was based on a given context, the group of items had to be included or excluded in toto.
3. The difficulty of each item (proportion of students missing the item) was required to be between .2 and .7.

4. Using the Individual Competency Measures scores to define the "upper 27 percent" and "lower 27 percent" groups, each item was required to have a minimum discrimination of .2.
5. The correlation of students' scores on each item with their scores on the Individual Competency Measures was required to be .2 or greater.

Out of the above items which met these requirements, 36 were used to make up TSPT. Although more items might have been included and would have been desirable from a strictly statistical viewpoint, experience gained during item try-outs indicated that if the number of items exceeded about 40, the students began to get restless and lose their concentration before they finished the test. TSPT was then printed and a machine scoreable answer sheet was designed and printed.

A summary of various correlations obtained from the above procedure is listed in Table 1.

Table 1 - Correlation Summary
N = 52

TSPT - ICM*	.830
TSPT - SRA** Science	.788
TSPT - SRA** Reading	.798

*Individual Competency Measures

**Science Research Associates Achievement Series (blue version)

Norming TSPT:

A Norming Sample was selected from the public schools containing sixth-grade classes as listed in the Michigan and Indiana public school directories and which are located within a 50 mile radius of Andrews

University in Berrien Springs, Michigan. From this population of 243 schools a random sample of 20 schools was drawn. One of these schools refused to participate in the study so the actual norming sample consisted of 19 schools from 12 different school systems. The sample contained rural, suburban and city schools in about equal numbers. The largest school contained 168 sixth-grade students and the smallest contained 21 sixth-grade students. There was a total of 1301 students in the norming sample, with a broad spectrum of science programs represented. Since no systematic relation was observed between students' scores and type of science program studied, no effort is made to distinguish among programs used by the norming sample. TSPT form D was administered to this norming sample by their own teachers in their own classrooms in the spring of 1974. The important test statistics obtained from the norming sample is displayed in Table 2. The distribution of student scores is given in Table 3.

Table 2 - NORMING SAMPLE DATA FOR TSPT

Grade level	6
Number of Items	36
Number of Subjects	1301
Median Score	17
Mean Score	17.9
Standard Deviation	6.90
Standard Error of the Measurement	2.69
Mean Point Biserial Correlation	.409
KR20 Reliability	.842
Mean Difficulty	.503
Mean Discrimination	.496

Table 3 - Norming Sample Distribution
N = 1301

<u>Raw Score</u>	<u>Frequency</u>	<u>Std. Score</u>	<u>Percentile</u>
36	0	+2.62	
35	0	2.48	
34	3	2.33	99.8
33	6	2.19	99.3
32	13	2.04	98.3
31	21	1.90	96.7
30	24	1.75	94.9
29	27	1.61	92.8
28	31	1.46	90.4
27	47	1.32	86.8
26	47	1.17	83.2
25	50	1.03	79.3
24	45	0.88	75.9
23	58	0.74	71.4
22	61	0.59	66.7
21	53	0.45	62.6
20	48	0.30	59.0
19	51	0.16	55.0
18	63	+0.01	50.2
17	59	-0.13	45.7
16	55	0.28	41.4
15	55	0.42	37.2
14	72	0.57	31.7
13	69	0.71	26.4
12	65	0.86	21.4
11	70	1.00	16.0
10	59	1.15	11.5
9	52	1.29	7.5
8	34	1.43	4.8
7	32	1.58	2.4
6	16	1.72	1.2
5	7	1.87	0.6
4	6	2.01	0.2
3	1	2.16	0.1
2	1	2.30	0.0
1	0	2.45	
0	0	-2.59	

TSPT is intended to be a "power test" so ample time should be given for essentially all students to complete the test. For the norming sample it was found that 45 minutes was adequate.

Reading Level:

Attention was given during item writing and editing to keeping the reading level as low as possible. The resulting reading level for the final test using the reading scale developed by Fry³ is approximately low sixth-grade.

In instances where classes were segregated on the basis of "good readers" and "slow readers" the "good readers" typically scored about 5 points higher than the "slow readers."

DIRECTIONS FOR ADMINISTERING TSPT:

TIME REQUIRED:

At least 45 minutes without interruption should be provided for the administration of TSPT.

TSPT is not intended to be a timed test. Thus you need not be concerned that all the students start and stop at exactly the same instant. Students should be encouraged to work efficiently but to take time to think through their answers. TSPT is not a factual recall test. Thinking is required to achieve a high score on this test. Most students will complete TSPT in less than 45 minutes.

MATERIALS:

The only materials the student will need in addition to the TSPT test booklet and the TSPT answer sheet are a pencil (number 2 is recommended) and an eraser.

MARKING THE ANSWER SHEET:

Since the answer sheets are intended to be machine scored, the student's response marks should be distinct and should approximately

³Edward B. Fry, Reading Instruction for Classroom and Clinic, (McGraw Hill, New York, 1972).

fill the response box without extending beyond it. A single dark mark is preferred. Mistakes should be erased cleanly. Although students should be encouraged to use reasonable care in marking, extreme concern on this point is not necessary.

USING THE NAME BLOCK:

First the student should turn the answer sheet sideways and print the letters for his name in the boxes provided at the top of the name block, one letter in each box. Care must be taken that the first letter of the last name is entered in the first box. If a student's name is too long to fit in the boxes provided, the last few letters should be omitted. In order for the machine to read the name, the letter in each alphabet column in the name block corresponding to the letter the student has placed in the box at the top of each column of the name block must be marked in. A single clean mark which approximately fills but does not extend beyond the response box is required. Only one letter may be marked in each column of the name block.

DIRECTIONS TO THE STUDENTS:

The directions to be given to the students are set off by vertical lines. These need not be read word for word, but may be paraphrased or amplified as desired.

Opening Statement:

This test will find out how well you can use the processes of science. That is, how well you can think and answer the way a scientist would. This means you will need to take time to think before you can answer the questions. You will have enough time so do not rush. If you work at a steady pace, you will have plenty of time to finish. The answer sheet will be handed to you first. Do not write on

it until you are told what to do. You will need a pencil with a good eraser for marking the answer sheet.

Distribute the answer sheets, one to each student. Check to see that each student has a pencil and an eraser.

Using the Answer Sheet:

Turn the answer sheet sidewise so the letters TSPT are at the bottom below the name block.

Hold up an answer sheet turned correctly.

Print your last name and your first name in the boxes at the top of the name block. Be sure you begin with the first box and put one letter in each box. If your name is too long to fit in the boxes, just leave off the last few letters.

Allow sufficient time for the names to be entered. Spot-check to see that it is done correctly.

Under the box where you printed the first letter of your name, go down the alphabet until you come to the first letter of your name. Draw a line through that letter. Be careful that your mark does not go outside the little box. Under the box where you printed the second letter of your name, go down that alphabet until you come to the second letter of your name. Draw a line through that letter. Do this for all the rest of the letters of your name.

Allow sufficient time for the name block to be filled. Spot-check to see that this is done correctly.

Turn the answer sheet right-side-up. You can see that there is one line on the answer sheet for each page of the test. For example, page one has only question one on it, while

page 2 has questions 2, 3, 4, and 5 on it, etc. You are to draw a line through the little box just below the letter which you feel is the one best answer for each question. If you make a mistake, erase it cleanly. Make your marks go the whole length of the little boxes, but be sure they do not go outside the little boxes. Since others will be using the test booklets, do not make any marks on them. As soon as you are given the test booklet, you may open it and go to work.

Distribute the test booklets. At the same time, check to see that the students have filled out the name block correctly.

DURING THE TESTING PERIOD:

Check to see that the students are marking the answer sheets properly.

FOLLOWING THE TEST:

Separate the test booklets and the answer sheets. Arrange the answer sheets in the order in which you wish the result returned to you.

Return all test booklets and answer sheets to R. Ludeman, Andrews University, Berrien Springs, Michigan 49104. The answer sheets will be machine scored and returned to you together with a computer printout of student's scores and test statistics similar to what appears in Table 2 of this manual. By special arrangement, other data may be obtained as well, such as item analysis information, breaking the test down into subtests, correlation of two sets of scores, etc.

INTERPRETING TSPT SCORES

Care should be exercised in using both tables 2 and 3 for interpreting the results of any administration of TSPT. The norming sample used to obtain these data should not be assumed to be representative of any wider population than that previously described.

PRINT YOUR NAME IN THE BOXES PROVIDED. THEN
BLACKEN THE LETTER BOX BELOW WHICH MATCHES
EACH LETTER OF YOUR NAME.

YOUR LAST NAME		YOUR FIRST NAME		M	
A	A	A	A	A	A
B	B	B	B	B	B
C	C	C	C	C	C
D	D	D	D	D	D
E	E	E	E	E	E
F	F	F	F	F	F
G	G	G	G	G	G
H	H	H	H	H	H
I	I	I	I	I	I
J	J	J	J	J	J
K	K	K	K	K	K
L	L	L	L	L	L
M	M	M	M	M	M
N	N	N	N	N	N
O	O	O	O	O	O
P	P	P	P	P	P
Q	Q	Q	Q	Q	Q
R	R	R	R	R	R
S	S	S	S	S	S
T	T	T	T	T	T
U	U	U	U	U	U
V	V	V	V	V	V
W	W	W	W	W	W
X	X	X	X	X	X
Y	Y	Y	Y	Y	Y
Z	Z	Z	Z	Z	Z

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FORM D
(1974)

INSTRUCTIONS:

1. Print your name in the boxes above.
If you have a long name, there may not be enough space for all of your name. That will not matter.
2. For each question in the test booklet, black in all of the box below the letter on this answer sheet which is the best answer.
3. Notice that the question numbers go across the answer sheet. There is one line on this answer sheet for each page in the test booklet.

Page 1:	1	A B C D			
Page 2:	2	A B C D	3	A B C D	4
					5
Page 3:	6	A B C D	7	A B C D	8
Page 4:	9	A B C D	10	A B C D	
Page 5:	11	A B C D	12	A B C D	13
					14
Page 6:	15	A B C D	16	A B C D	17
					18
Page 7:	20	A B C D	21	A B C D	22
Page 8:	23	A B C D	24	A B C D	25
					26
Page 9:	29	A B C D	30	A B C D	31
					32
Page 10:	34	A B C D	35	A B C D	36